disease and are more pronounced than those in cases previously recorded, and both base and vault are involved. The exophthalmos of the left eye is due to the frontal-bone growth displacing it forward; Albright described a similar instance. No involvement of the inner table of the skull is seen and the pituitary fossa appears to be normal. The cyst-like spaces and trabeculation and expansions of the occipital region and the "blister" appearance on the surface of the parietal bones show the results of an active phase of the disease. The hyperostosis in the vault is similar to that of early Paget's disease; while the solid replacement of the mastoid cells and the surface growth in the sphenoidal air sinus would seem to conform to the osteitis fibrosa of the creeping periostotic type of leontiasis ossium described by Lawford Knaggs. Had the disease in the present case involved the maxillary sinuses and, more typically, the facial bones, it might have been considered a definite example of leontiasis ossium. Cases of leontiasis ossium with involvement of other skeletal bones have been described ("Osteitis Fibrosa Generalisata as a Complication of Leontiasis Ossium and Coxa Vera": *Sei-I-Kai M.J.*, abstract section, Dec., 1936, 55, 1).

Finally, it may be thought that, instead of the fibrocystic diseases of bone being classified according to the region involved and the extent of the bone changes, many of them may be regarded as part of an abnormal parathyroid activity induced by alterations in the factors governing its metabolism and with trauma or vascular conditions playing a localizing part.

Summary

A case of osteitis fibrosa disseminata showing involvement of the skull and the right humerus and associated with certain blood changes is reported. It is suggested: (a) that the condition is one of endocrine abnormality in which the parathyroid hormone is dissociated from the normal endocrine balance; (b) that abnormality in the region of the pituitary or hypothalamus is the exciting cause and this may be due to haemolytic disease of the newborn; and (c) that the fibrocystic diseases of bone may be interrelated and their causal factors found in the different influences affecting parathyroid metabolism.

Previous history of icterus gravis neonatorum may be sought and a check made of the maternal Rh. Prolonged observation of the patient may reveal that the fibrocystic diseases of bone have periods of recrudescence and intermission.

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OCCUPATIONAL DISEASES OF THE LENS AND RETINA*

BY

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This paper deals only with the diseases of the lens and retina that occur amongst glass and furnace workers, welders, and others exposed to excessive radiation at their work.

Radiant Energy and its Effects on the Eye

The visible rays occupy only a small portion of the radiation spectrum. The whole range of electro-magnetic radiation extends from the long electro-magnetic waves used in wireless and industrial high-voltage currents to the short gamma rays emitted from radium, uranium, and also during nuclear disintegration of atoms. Next to the electro-magnetic waves are the infra-red rays, which are generated by heated bodies (metal, glass, etc.) and are a source of danger to the eyes in foundries, glass factories, etc.

The long infra-red rays are mostly absorbed by the cornea. The short infra-red rays are transmitted through the cornea and are absorbed by the lens; a small part of these rays, however, reach the retina. The infra-red rays when absorbed by the tissues of the eye cause an increased activity in the tissue cells, and with it an overheating of the tissues. The cornea, which is air-cooled, suffers from no ill effects. The lens, on the other hand, when overheated through absorption of the short infra-red rays, undergoes marked changes, resulting in the formation of cataract. This form of "heat cataract" is found amongst glass-blowers, chain-makers, and foundry and furnace workers. The iris and ciliary body also absorb a good deal of the short infra-red rays; the heat generated in these tissues, however, is lost to the circulating aqueous.

The visible rays of the sun pass through all the media of the eye and on reaching the retina set up a series of biochemical changes which the brain interprets as vision. An excessive exposure of the eye to the sun rays may cause pathological changes in the eye.

The short and the long ultra-violet rays are absorbed by the cornea and the ocular conjunctiva, and only a very small amount of ultra-violet rays reaches the aqueous and the lens. The short ultra-violet rays set up biochemical changes in the conjunctiva and the cornea which manifest themselves "after a latent period" of several hours as a conjunctivitis or a keratitis. These ultra-violet rays are present in high quantities in welding arcs (gas and electric welding), and are responsible for the "arc eye" which is extremely common amongst welders.

The x rays and gamma rays are of very short wavelength; they penetrate the tissues of the eye and have a direct action on the lens, causing the formation of a cataract. Vascular changes are also set up in the iris and the ciliary body.

Occupational Eye Diseases due to Radiant Energy

In the past glass-workers have been known to develop cataract. In glass-bottle making the finisher was exposed to the undiminished glare of the furnace or tank of molten glass. The infra-red rays emitted by the molten glass were

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absorbed by the lens, and after many years the glass-workers developed typical "heat cataract." Investigations by Dr. Robinson and Sir Thomas Legge in 1908 showed that 20% of glass-workers had lens changes. These investigations have led the Government authorities to recognize "glass-blowers' cataract" as an occupational disease, and it is now scheduled as such under the British Workmen's Compensation Act, 1929. The recognition of this eye disease and the discovery that it is due to infra-red rays (heat rays), and not as previously thought to the ultra-violet rays, have led to further investigations into the means of its prevention.

Physicists found that glass to which metallic oxides are added can absorb about 90% of heat radiation. This glass, which is dark green, should be used in goggles and protective screens. Many glass-workers still use dark blue glasses which do not absorb a great deal of infra-red radiation.

Protection of the workers is best achieved by using machines which incorporate protective measures. This guiding principle inspired the inventors of the modern machines which are used in the making of glass bottles. The machine automatically sucks up the molten glass, blows the glass, and delivers the bottles at the rate of 40 a minute. The use of these machines is responsible for the great drop in the incidence of cataract amongst glass-workers. In Great Britain during the period 1939-45 only 27 cases of cataract were notified in the glass industry to the Ministry of Labour. In the year 1945 only one new case of cataract was notified. These figures were supplied to me by Dr. Merewether, Chief Medical Inspector of Factories in Great Britain, by the kind permission of the Ministry of Social Insurance. These figures should be compared with those of "glass-blowers' cataract" found by Dr. Robinson 40 years ago.

"Heat Cataract" in Metal Industries

Investigations carried out by ophthalmologists in many countries have now fully established the fact that workers in various metal industries, whose eyes are exposed to the heat from molten or red-hot metal, develop cataract. In Great Britain cataract caused by "exposure to rays from molten or red-hot metal" is now scheduled as an industrial disease.

In the years 1939-45 there were 131 compensation cases of cataract in the metal industry, while in the glass industry there were only 27 cases. In 1945 there were 16 cases of cataract in the metal industry, and only one case in the glass industry.

Evidently very little is being done in the metal industry to prevent the development of "heat cataract." I have visited several foundries in and around London, and have found that the eyes of the furnacemen and foundrymen were exposed to the heat of the molten metal. No eye protection was used by them. In some foundries electric furnaces are used, and the workers looking after these furnaces inspect the molten metal for very short periods only; but the furnacemen looking after gas-heated furnaces are exposed to the heat of the molten metal for many hours a day without any eye protection. Only through adoption of efficient means of protection of the workers' eyes will the number of cataract cases in metal industries diminish.

Chain-makers' Cataract

In Staffordshire there are about 1,200 people working at chain-making, hand forging of chains. In 1921 Dr. Roberts, ophthalmologist of that district, reported that "heat cataract" is common among chain-makers. Since that date a number of cases of "chain-makers'

cataract" have been reported by many other observers.

The workmen do not seek advice until their vision has become poor. At the age of 50 or over, by which time the chain-maker has been at his trade for some 35 years, lens changes typical of "heat cataract" often occur. It is interesting to note that the lens changes progress even if the chain-maker leaves his trade.

Dr. Lloyd Johnstone, ophthalmologist in Staffordshire, has seen 50 new cases of "chain-makers' cataract" during the past 10 years. The workmen are often advised to use dark glasses or goggles provided with "infrex glass" at their work, but they always claim that they cannot work with glasses, and it is very difficult to persuade them to do so while their sight is good.

Eye Hazards in Electric and Gas Welding

The most common types of welding used in industry are gas and electric welding. In gas welding oxygen or acetylene is used. Acetylene produces one of the hottest flames (6,000° F.—3,315° C.); oxygen welding reaches a temperature of 4,000° F. (2,204° C.).

All welders have at some time suffered from "arc eye," or "welders' flash." This condition is due to the exposure of the unprotected eye to the ultra-violet radiation of the arc in gas welding or electric welding. The welder is exposed to the radiation of his own work and to the reflected radiation from neighbouring workers. On examination one finds a conjunctivitis with an occasional superficial keratitis. The extent of the corneal involvement will depend on the length of the exposure to the arc and on the intensity of the radiation. The acute symptoms usually last one to two days. Repeated exposures to the arc produce a chronic blepharo-conjunctivitis with a chronic keratitis. The presence of the latter condition is often missed. A careful examination of the patient with a slit-lamp microscope will in such cases show the presence of multiple corneal erosions which stain with fluorescein.

The great heat generated by the welding arc is the source of intense infra-red radiation. Some of this radiation is absorbed by the eye and transformed into heat energy. Although most of this energy is absorbed by the cornea and conjunctiva, some of it (4 to 6%) may be absorbed by the lens. The lens cannot lose heat as easily as other parts of the eye and serious injury of the lens may follow.

Opinions are divided about the frequency of cataract among welders. However, many observers claim that lens opacities of the same type as have already been described occurring among furnacemen are to be found in elderly welders. Welders who may be suffering from some general disease or those whose state of nutrition is poor are liable to greater damage of the lens as a result of such physical factors as infra-red radiation. Eye injuries due to infra-red rays will go on occurring until better protective equipment is provided for the welders.

Retinal Injuries from Infra-red Radiation

Retinal injuries among welders are rare, but a number have been recorded. In these cases the central part of the retina shows definite changes. They may vary from a slight haziness of the macula to a pronounced oedema. The patients usually complain of a partial loss of vision, they may be aware of seeing a black spot in the centre of vision of one or both eyes, and their central vision may be very poor. Cases of mild oedema of the macula may fully recover; on the other hand, severe burns of the macula have led to a complete or partial loss of central vision. Ophthalmoscopic examination of the eyes many months after such an injury may show no macular changes, or a slight granular

appearance of the macula may be seen. In severe cases a "retinal hole" may be found at the macula.

I recently saw two men who were suffering from retinal burns from the welding arc. These patients were shown at the Congress of the Ophthalmological Society of the United Kingdom in March, 1947. Dr. White's patient was a fitter who was working 6 feet (1.83 metres) away from the welding arc. He had no eye protection when the arc was struck. A few days later he complained of blurred vision of one eye. He was seen a few weeks after the accident, and he then had a typical oedema of the macula, which later subsided. I saw him several months after the accident, and he then had an excavation (a hole) at the macula of one eye. The other patient, shown by Dr. Spence Meighan, was a welder. He attended at the Glasgow Eye Infirmary on March 16, 1945. He then complained of blurred vision of the right eye. His eyes were exposed to a flash from electric welding three days earlier. He had an oedema of the right macula. The vision of the right eye was 6/9. The left retina was normal; vision was 6/5. The oedema of the right macula subsided within a few weeks. The vision improved to 6/6. He now shows a fine pigmented disturbance at the right macula, and he has a small absolute scotoma at the point of fixation.

The retinal burns described above are largely produced by infra-red radiation of the welding arc. Investigations on the transparency of the ocular media to the radiation of various wavelengths have shown that 12% of the infra-red radiation of the welding arc reaches the retina of the unprotected eye.

Eye Injuries due to High-voltage Electric Currents

Burns of the body by high-tension electric currents are known to be sometimes followed by the formation of cataract in one or both eyes. A number of such cataracts have been reported by ophthalmologists. Such injuries occur in high-power electric stations where electricity is either produced or distributed.

The rarer type of injury to the retina may occur when a workman's eyes are exposed to a sudden electric flash from a high-voltage electric current. The following two cases illustrate the salient points of "electric eye injuries."

Case 1

An electrical fitter aged 39 was working in a trench on Jan. 27, 1946, repairing switch gear in a transformer substation. The voltage of the electric current in this station was 6,600. As a result of a short-circuit he was severely burnt; he was pulled out from the trench in an unconscious state and was admitted to hospital, where he remained unconscious for six hours. He was suffering from severe burns of the right side of the face, the right side of the scalp, and the right arm. He was away from work for three months. A week after his return to work he noticed a slight mistiness of vision of the right eye. He was then examined at an eye hospital, where he was found to be suffering from lens opacities of the right eye.

I examined him for the first time in March, 1947, fourteen months after the accident, and found the following: *Right eye:* Vision 6/24. The cornea and iris were normal. The slit-lamp microscope showed a dense central opacity in the anterior lens capsule and the underlying lens cortex. The peripheral parts of the anterior lens surface showed faint opacities, as though a veil was spread over the lens surface. The posterior cortex of the lens showed early changes. *Left eye:* This was normal in all respects and the vision was 6/5.

I examined him again in October, 1947, and he then told me that since August the vision of the left eye was not as clear as it used to be. Slit-lamp microscope drawings were made of both eyes. The left lens showed hundreds of small opacities on the anterior surface of the lens. The optical section drawing showed these opacities to be confined to the anterior lens capsule. The vision of the left eye was still 6/6. The drawing

of the right eye showed that the central lens opacities had become much denser. The optical section drawing also showed a pronounced thickening of the central part of the anterior lens capsule.

The outstanding features of this case are: (1) The right lens developed "an electric flash" cataract three months after the injury. (2) The left lens remained clear for eighteen months and then, about twenty months after the injury, it began to show lens opacities. These will most probably increase and will eventually cause the loss of vision of this eye.

Similar cataracts have also been reported in people who were struck by lightning. The causation of the "electric cataract" has never been satisfactorily explained. It is most probably due to chemical changes in the ciliary body of the eye and the lens capsule during the passage of the high-tension electric current through the body.

"Electric flash cataract," as a result of an exposure of the workman's eye to a powerful electric flash, is rare, but a few cases have been reported in the past. Retinal injuries from electrical flashes are much more common. The following case illustrates this condition.

Case 2

A man aged 25 was working on Nov. 29, 1946, on a switch gear of an electric generator. A short-circuit in the switch gear caused a powerful electric flash. He suffered from no general ill effects; he was not burnt. Three days later his left eye was slightly red and painful and he could not see with it. He was examined four days after the exposure to the electric flash. The vision of the left eye was then reduced to perception of light. The cornea, iris, and lens were normal. The central part of the left retina was oedematous. There were no retinal haemorrhages or exudates. The right eye was normal and the vision of this eye was 6/5.

A few weeks after the accident the vision of the left eye began to improve and the retinal oedema gradually subsided. He was away from work for three months. One year after the accident the vision of the left eye was 6/9, the oedema of the left central retinal area had subsided, and the macula had a granular appearance with a few pigmented dots.

These retinal changes resulting from electric flashes have been attributed by various observers to the infra-red radiation and to the intense visible light rays. It is impossible to state which of those rays are primarily responsible for the damage to the retina. The intensity of the light from a short-circuit has been estimated to be equal to the light of 150,000 candles; it is therefore probable that the photo-chemical changes produced by this intense light play an important part in producing the retinal changes.

Industrial Uses of X Rays and Radioactive Substances

X rays are used nowadays in many industrial processes—for example, in the examination of metals, micas, rubber products, textiles, etc.

The recent research on atomic energy demands a vast expansion of the work of extracting uranium and other radioactive substances from minerals. Great care must be taken to protect these workers from the dangerous effects of radioactive substances. If such care is not taken we shall soon read reports about severe anaemias and cataract of the eyes among the workers in these industries.

The Ministry of Health has sent a circular to local authorities and medical officers of health pointing out that two short films—one on diphtheria immunization and the other on burning and scalding accidents to children—may be borrowed free from the National Screen Service, Wallace House, 113, Wardour Street, London, W.1, if a cinema manager will include them in his programmes. They have been sent out before, but in some cases have been cut from the newsreel for various reasons. When asking for the films, three weeks' notice should be given of the date when the cinema manager has agreed to show them. They will be sent direct to the cinema.